ANNEX 4

Microcomputers and Fisheries

by

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1. INTRODUCTION

Research and management relating to living resources require extensive data bases. Because of the multiplicity of species, fishing gear and participating nations, fisheries research and management activities may require much more data than any other resource management area. This situation led fisheries scientists and managers to embrace good record-keeping practices and to apply statistical survey procedures. The resulting large depositories of data contributed materially to the development of quantitative techniques for fishery stock assessment in the early 1900s. The ever-increasing size of the data sets created problems in processing and managing them in a timely and cost-efficient manner. With the development of the computer during World War II and its commercial availability shortly thereafter, a new tool became available for managing and processing these large fisheries data sets.

Fisheries workers adopted this new tool, learned high-level programming languages, such as FORTRAN, to process their data, and proceeded in an effort to gain access to ever bigger, more powerful mainframe computers.

In the middle to late 1970s, developments occurred in the computer field that are only now being recognized and adopted to any great extent in fisheries. These developments include: (1) maintenance of data sets in mass storage devices (disks) attached directly to computers rather than on magnetic tapes to facilitate speedy access for updating or analysis; (2) interactive rather than batch processing; (3) availability of smaller computers called minicomputers; and (4) time-sharing of processing resources on a mainframe computer.

Two recently occurring computer developments are not, except for a few instances, being used in fisheries. One involves a concept called distributed processing, where two or more small computers perform site specific processing but are linked together in a network for sharing of data bases and, sometimes, the processing power of a central, large computer. The second event, which is the subject of this paper, involves the development of the general purpose microcomputer.

In this report, I will describe the general purpose microcomputer, discuss its capabilities, compare its performance specifications to some minicomputers, and finally present some fisheries applications of microcomputers.

In discussing computers, it will be necessary to use words and terminology unfamiliar to most fisheries workers. To make matters worse, the computer field is rich in jargon that is evolving as rapidly as the field itself. I will attempt to avoid as many of the specialized terms as possible but the use of some will be necessary. To facilitate our communication, I have included a short glossary (Appendix 1), which I extracted mostly from McGlynn (1979) and Popular Computing (1981).

2. THE MICROCOMPUTER

2.1 Some Definitions

What is a microcomputer? And, what makes it different from the computers we fisheries scientists have been using all these years? The glossary presents the text book definition, but further explanation seems in order.

A computer system, besides essentially being an assemblage of machines whose purpose is to process information, is made up of several devices - some for inputting information, some for storing if, some for outputting it, and one for processing it. The latter is generally called the central processing unit (CPU). It is the heart of the computer and is purely electronic, not electro-mechanical. The CPU is in turn made up of an arithmetic logic unit, some registers for temporary storage of data, instructions and address (much like the registers on a calculator), an instruction decoder and timing unit (determines what part of the CPU is instructed to do something and when), sometimes a clock, a memory and input-output controller (for communicating with random access memory and the input-output interface), and communication wires (called buses; for transmitting data, addresses and control instructions).

Large mainframe computers or maxicomputers, for example the IBM[1/], Univac and Burroughs machines which have been used for so many years, are products of the electronics industry. In these machines, the CPU is made up of separate electronic units linked together inside a cabinet to accomplish each of the functions of the CPU given above. These units of boxes have gotten smaller over the years, but they are still separate electronic units. In minicomputers, a great advancement was made in miniaturization so that the arithmetic logic unit, the registers, and the instruction decoder and timing unit could be placed together on an electronic board. These electronic boards not only take less space than the electronic units of the maxicomputers, but they are cheaper to manufacture and are more dependable.

Microcomputers are products of the semiconductor industry and are fundamentally different from both mini- and maxicomputers. In this case, all of the processing functions of the CPU are placed together on a single silicon chip smaller than your fingernail. Hence, the phrase "computer on a chip". Technically, the silicon chip is a microprocessor. This chip is placed on an electronic board along with part or all of the random access memory, the clock, the input-output interfacing unit, and extensions of the communication buses. Hence, the entire CPU can now reside on a single electronic board although frequently part of the random access memory is placed on a separate board. This arrangement is cheaper to manufacture and more dependable than that used in the minicomputer.

Thus, the basic difference among maxi-, mini- and microcomputers is the electronic architecture. What about using processing capacity as a means of defining these types of computers? In general the maxicomputers are capable of doing more processing faster than mini- or microcomputers. However, as minicomputers improved, they became capable of performing the same work in less time and at less cost than smaller, less capable maxicomputers. Hence, the more efficient minicomputers have displaced the less efficient maxicomputers from the market place. Similarly, advances in microcomputers have resulted in the displacement of the smaller, less capable minicomputers. Today, a microcomputer costing US$ 2 000-3 000 is more powerful, faster and more compact than the first computer costing millions of US dollars. The processing power of each of the computer types is advancing rapidly and will continue to do so for the foreseeable future; hence, processing power is not a good means for characterizing types of computers.

1/ Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA

2.2 Some Early Uses

The microprocessor was originally created to handle routine, set tasks commonly used in controlling manufacturing processes. It was only later that the microcomputer, encompassing the microprocessor, was used for manufacturing, business, and scientific applications. Some of the first applications of microprocessors in science were to interface between laboratory or field instruments and some recording device or a computer. In fisheries and oceanography, microprocessors are used with instruments measuring temperature, conductivity, pressure, current, and weight. In such instruments, they can be used to control the rate at which the sensory instruments operate, to convert the devices' analog signals to digital signals for subsequent analysis on computers, and to filter, smooth or average data generated by sensory instruments. They calculate salinity from temperature, pressure, and conductivity readings and the position of ships from satellite signals (see Mini-Micro Systems 1979 for a description of a forerunner to the off-the-shelf satellite navigation instruments that are available today). They can be used to estimate the potential amount of naturally occurring fish food by counting free-fall particles (Lasker and Brown, 1978).

Increasingly, microcomputers, rather than microprocessors, are being built into laboratory and field instruments because they can be programmed to handle variable situations including the changing of work performed by the instruments in response to changes in the factors being measured. For this reason, microcomputers are being employed in oceanographic data buoys (Lobecker et al., 1978), in unmanned underwater vehicles (Marine Industrial Advisory Service, 1980) and echo-sounder integration systems to estimate fish abundance (Kanemori and Ehrenberg, 1978; Iida and Susuki, 1980). Although these machines are programmable, they are essentially dedicated to one particular kind of task.

2.3 The General Purpose Microcomputer

Of greater significance to fisheries workers today is the availability of powerful, but relatively inexpensive, general purpose microcomputers. Sometimes they are called desk-top computers, but the largest reside in cabinets. Most are 8-bit machines (that is, they use eight binary digits consisting of either 0s or 1s to represent numeric data, alphabetic letters, and special characters), although 16-bit machines are becoming more common. Some of these microcomputers are capable of supporting several users whereas others only one user. The latter are called personal computers.

In the following paragraphs, I will state some of the advantages of personal and multiuser microcomputers, comment on available computer programming languages, describe several commercially available computer program packages, and end with some brief material on communicating with other computers and sensory instruments.

The great advantage of a personal computer is that it is available for immediate use at any time for nearly any application the user wishes. Unlike users of large computers, the personal computer user does not contend with slow response time of inability to gain access to the computer because too many users are on the system. Neither is the user of a personal computer subject to processing expenses or operator-imposed restrictions associated with large computers.

The multiuser microcomputer also has several advantages. Since such computers are usually dedicated to a small group of associated users rather than to some organization-wide support group, they are available for use at the convenience of the group. Computer programs and data sets can easily be shared. Peripheral devices, such as disks, a painter, and a graphics plotter can be shared, thus lowering the overall cost. Of course, only one user can utilize these paripherals at any one time.

BASIC is the most commonly used programming language, but many microcomputers can be programmed in several other high-level languages such as FORTRAN, COBOL and PL/I. In addition, several new structured programming languages, for example, Pascal, are becoming available for microcomputers. High-level languages allow the user to program the computer to perform almost any type of processing task imaginable.

Many new computer programs (or software) are becoming commercially available that significantly increase the utility of these machines to fisheries workers. Previously, software for data entry, file management and data-base management were available only on mainframe computers. Without such software for microcomputers, it was very laborious to enter data and manage the data sets for subsequent analysis. Now, there are several commercially available software packages for microcomputers that allow the user to set up data entry formats, manage individual data sets, or combine data sets or elements from several data sets for subsequent analysis. While these currently available packages are not as powerful as those for mainframe computers, they have significantly increased the usefulness of the microcomputer and the productivity of its users. With more powerful 16-bit microcomputers becoming available, this situation should improve.

Some statistical software packages exist for performing simple parametric and non-parametric analyses including time-series analysis. However, these packages generally are not very powerful because of limited machine memory, language-based restrictions on the number of significant digits that can be carried in calculations, and poor data entry and management procedures. Very few quantitative fisheries applications have been programmed onto microcomputers, but is should be fairly straight forward to do so. Again, with the entry of more powerful 16-bit microcomputers, more sophisticated statistical software should become available, and it should be possible to program all but our most complicated stock assessment methodologies onto these computers.

Most of the statistical software also have the ability to plot the data used in the analyses and the results from the analyses. Needs in the business world have resulted in software capable of producing pie charts and bar graphs, in color if you wish. Needs in the automotive, aircraft, and communication industries have resulted in the development of graphics software capable of displaying three dimensional charts, expanding views of selected areas of a display, rotating figures, and changing the angle of view. Thus, the available software is probably capable of handling any fisheries application; but the technology must be transferred to fisheries. Graphic representations of data can be displayed on monochrome or color video terminals or can be sent to graphics printers or plotters. The cost of these devices, particularly graphics printers, has decreased substantially the last couple of years, thus making them available to many more users. Relatively inexpensive color graphics printers are now available.

The microcomputer industry has created a unique type of software that has not as yet been implemented on larger computers. This software allows the user to set up a grid of columns and rows that can be mathematicaly interrelated according to the user's specifications. If the user wishes to see the consequences of changing some of the numbers entered into the spread sheet, he merely enters the new numbers and the rest of the table is recalculated. Thus, simple simulating can be programmed in minutes rather than hours using regular high-level languages.

The last type of microcomputer software that I will discuss, word processing, has tremendous utility in fisheries. Although this software accomplishes a task that is technically not part of fisheries or any science, word processing can reduce the time spent writing scientific documents. To produce this paper, I outlined what I wanted to say, collected information from the literature to supplement what I wanted to say, prepared a more detailed outline, and then sat down in front of a microcomputer and wrote the paper. The software allowed me to edit various sections, make insertions, and move whole sections around before I was satisfied with the document. When I passed the text file containing the document to the secretarial staff for finalization, they did not have to decipher cross outs, insertions, and arrows pointing in various directions. When they finished their work, I did not have to check for introduced typing errors. It is much easier and faster to prepare documents using word processing than by any other method. Word processing can be accomplished on micrcomputers, dedicated word processors, or mainframe computers, but these latter devices are less available to individual scientists.

Devices called modems and the software to support them allow the user of a microcomputer to communicate with other microcomputers or with mainframe computers. This facility essentially turns the microcomputer into a terminal which can then be used to transfer data sets to or from a mainframe computer and to conduct analyses directly on the larger computer. In addition, software is available for some microcomputers making it possible for them to function as a remote job entry station to a mainframe computer (2780/3780 protocol emulator). The capability of a microcomputer to emulate a terminal or a remote job entry station is extremely useful because it allows the microcomputer user to manage and process very large data sets on the mainframe computer and then use the microcomputer to process compacted data retrieved from the larger computer.

Most general-purpose microcomputers have the ability to interrupt ongoing processing and interrogate scientific measuring instruments, store or process the data received, and then return to the other task it was performing. Thus, the microcomputer can be used to control or conduct experiments while still being used as a data processing computer.

2.4 Comparing Microcomputers and Minicomputers

In the material presented above, I called the microcomputer a powerful tool and discussed some of its capabilities in terms of available software for data processing. To put things into perspective, I will compare specifications and costs for the basic hardware comprising a minicomputer and a microcomputer. For this comparison, I will use two tables listing the features of several minicomputers that were prepared by the International Commission for the Conservation of Atlantic Tunas (ICCAT) in 1978 and the Food and Agriculture Organization (FAO) Project for Tuna Management in 1980. The minicomputer procured by the Skipjack Assessment Programme of the South Pacific Commission (SPC) is included in these tables. The microcomputer used in the comparison is produced by Integrated Business Computers, a relatively small manufacturer in the US. Although this is a sophisticated system, it is not unique in the United States, Japan or Europe.

In 1978 the SPC acquired a Hewlett-Packard (HP) 1000 model 45 minicomputer to support their tagging activities. At the time, this computer represented the state of the art for mid-range minicomputers. In the same year, ICCAT prepared a paper comparing the capability and cost of several minicomputers (including the HP 1000) to the costs of time-share services from Computer Sciences Corporation's Information Network (Nordstom and Miyake, 1978). The hardware specifications and costs for the minicomputers are reproduced in Table 1. In 1980, FAO's Project for Tuna Management prepared a similar table comparing the features and costs of minicomputers for consideration by the tuna committees of the Indo-Pacific Fisheries Commission and the Indian Ocean Fisheries Commission (Skillman, 1980). By today's standards, these minicomputers (Table 2) no longer represent the state of the art, and they fall into the lower range of the capability of minicomputers.

It can be seen from Tables 1 and 2 that the cost of these systems has decreased substantially. In 1978, the cost of the basic HP system was nearly US$ 100 000. The least expensive system, the IBM, cost about US$ 88 000; the most expensive, Digital, cost US$ 106 000. By 1980, HP had become the least expensive system, costing only about US$ 58 000. The most expensive was the FACOM at over US$ 91 000.

From Table 3, it can be seen that the IBC microcomputer compares favorably with the minicomputers listed in Tables 1 and 2 in terms of central processor memory (its maximum memory is significantly less than the largest of the minicomputers, however), cycle time (a measure of internal speed; significantly faster than any of the minicomputers), and disk-storage capacity. The manufacturer's specifications did not give the density of the 9-track tape drive, but it is probably no more than 800 bits per inch (bpi), which is the same for the minicomputers listed in Table 1. Also, the disks may be slower than those used with minicomputers. Specifications are not the whole story, but this 8-bit microcomputer does compare reasonably well with the minicomputers listed.

For a number of years now, the 8-bit microcomputer has been dominating the market; however, the microcomputer field is undergoing a revolution because of the introduction of the 16-bit microprocessor. Today there are at least 20 microcomputers using these more powerful microprocessors. These new microcomputers are not only faster, but more importantly they can directly address much more memory (1.0 Mbytes or more as compared to 64 Kbytes). All or most of the minicomputers listed in Tables 1 and 2 are 16-bit machines. As the manufacturers of 16-bit microcomputers improve their products and make them more sophisticated, the 16-bit microcomputers will undoubtedly displace minicomputers of the level discussed here. In addition, two manufacturers have announced 32-bit microprocessors, and one indicated that manufacturing would start in 1983.

3. RECENT FISHERIES APPLICATIONS USING MICROCOMPUTERS

General purpose microcomputers are being used in fisheries to an increasing extent, including the Central and Western Pacific. As an illustration of this, I will present below the three recent applications.

3.1 Western Pacific Fisheries Information Network

With the passage of the Magnuson Fishery Conservation and Management Act in 1976, Federal and State fisheries managers have experienced an increasing need for data on fisheries resources in the US Fishery Conservation Zone. Accurate data are needed on a timely basis for management decisions and the preparation of fishery management plans. Managers and scientists in the National Marine Fisheries Service (NMFS), the Western Pacific Regional Fishery Management Council, and state and territorial fisheries agencies have encountered problems due to the lack of a historical data base, unavailability of existing data for analysis, legal constraints for data exchange, lack of data standardization, and inadequate procedures for data collection. The Southwest Fisheries Center started the Western Pacific Fishery Information Network project to solve these problems[1/]. Specifically, the purpose of the project is to (1) enchance and modernize the existing systems for fisheries information management and data collection; (2) develop and implement new systems for information management and data collection; (3) establish both central and distributed, computerized data bases; and (4) establish a communication network among state, territorial, and Southwest Fisheries Center data collection and processing groups for access to, and exchange of, the computerized data bases. The agencies included in the network are, in addition to the Honolulu Laboratory of the Southwest Fisheries Center, the American Samoa Office of Marine Resources, the Northern Mariana Islands Department of Natural Resources, Guam Division of Aquatic and Wildlife Resources, and Hawaii Division of Aquatic Resources.

The network is a distributed computer system consisting of a central minicomputer and satellite microcomputers (Figure 1). The central minicomputer system consists of a Digital Equipment Corporation PDP 11/70 accessed on a time-share basis using video display terminals or a microcomputer. The distributed microcomputer systems consist of Apple II Plus microcomputers each with twin 5-1/4 inch (13.3 cm) floppy disk drives, a dot matrix printer, and a video screen. Micromodems are included with the microcomputers located at the Honolulu Laboratory and the Hawaii Division of Aquatic Resources.

A similar network is being set up by the National Marine Fisheries Services' Southeast Fisheries Center for essentially the same purpose. This network will involve all the States in the southeastern US and will include data on fisheries resources under US jurisdiction in the Gulf of Mexico, the Caribbean, and off the southeast Atlantic coast.

3.2 Resource Assessments in the Indo-Pacific Region

The International Center for Living Aquatic Resources Management (ICLARM) is conducting several studies involving the assessment of demersal and pelagic fish stocks in Southeast Asia. Recently, Pauly (1981) indicated that they are establishing a microcomputer-based

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1/ Hamm, D.C., Preliminary description of the Western Pacific Fishery Information Network. 1982 Admin.Rep.Southwest Fish.Cent.NOAA/NMFS, (H-82-2):11 p.

system for filing trawl survey data on fisheries in the region and for their analysis by local scientists. In this same paper, Pauly also announced the availability of microcomputer software to calculate von Bertalanffy growth parameters and catch curves from length-frequency data.

3.3 Laboratory Research on Tuna in Hawaii

At the Kewalo Research Facility of the Honolulu Laboratory, microcomputers are being employed in experiments involving physiological parameters, environmental variables such as temperature, feeding preferences and rates, and electromagnetic fields. The microcomputers are interfaced with sensing devices to determine the movement and other bahavioural responses of captive animals being subjected to various experimental procedures. The microcomputers are programmed to analyse the bahaviour of the experimental fishes and alter the experiment in response to the fish's behaviour. In this way, the experimental animals' preference for environmental factors such as temperature have been determined. The ability of skipjack tuna, Katsuwonus pelamis, and other tuna to sense changes in the earth's electromagnetic field, is being investigated to determine their ability to use this environmental cue for migration.

4. LITERATURE CITED

Iida, K. and T. Susuki, 1980 Study about quantification of echo-sounder signals. 1. A signal acquisition of an echo-sounder. Bull.Fac.Fish.Hokkaido Univ., 31:339-53

Kanemori, R.Y. and J.E. Ehrenberg, 1978 A microcomputer-based echo-integration system for fish population assessment. In Oceans' 78. New York, Marine Technology Society and Institute of Electrical and Electronics Engineers, pp. 204-7

Lasker, R. and J.C. Brown, 1980 Free-fall particle counter for ocean surveys. Rep.Calif. Coop.Ocean.Fish.Invest., (21):207-10

Lobecker, R.N. et al., 1978 Real-time oceanographic data from Georges Bank. In Oceans' 78. New York, Marine Technology Society and Institute of Electrical and Electronics Engineers. pp. 536-46

Massachusetts Institute of Technology, 1980 Marine Industry Advisory Service, Some federally sponsored research programs for unmanned underwater vehicles. Opportunity Brief 18 MIT Sea Grant Program, (80-5):34 p.

McGlynn, D.R., 1979 Personal computing. Home, professional, and small business applications. New York, John Wiley and Sons, 263 p.

Mini-Micro Systems, 1979 One-board computer directs skipper to tuna. Mini-Micro Syst., 12(4): 90-1

Nordstrom, V. and P. Miyake, 1978 A comparative study of the mini-computer and the conventional data processing system. Collect.Vol.Sci.Pap.ICCAT/Recl.Doc.Sci.CICTA/Collecc. Doc.Cient.CICAA, 8:560-6

Pauly, D., 1981 Tropical stock assessment packages for programmable calculators and micro-computers. ICLARM Newsl., 4(3):10-3

Popular Computing, 1981 In other words. Popular Computing, 1(1):104-11

Skillman, R.A., 1980 Progress report of UNDP tuna specialist including reports on site visits to assemble statistics and a discussion of a computerized statistics system. Paper presented at the Sixth Joint Meeting of the Indian Ocean Fishery Commission, Committee on Management of Indian Ocean Tuna, 7th Session, and the Indo-Pacific Fishery Commission, Special Committee on Management of Indo-Pacific Tuna, 6th Session, Perth, Australia, 20-22 February 1980. Rome, FAO, IOFC/IPFC:TM/80/Inf.4:44 p.

APPENDIX 1

Glossary

Analog. In the computer field, the use of electric voltages as physical analogues of numerical variables.

Architecture. Organizational structure of a computing system, mainly referring to the CPU or microprocessor.

BASIC. The most popular high-level language used on microcomputers. Short for "Beginner's All-purpose Symbolic Instruction Code".

Bit. An abbreviation of "binary digit"; single characters of a binary number, either 0 or 1 in the case of computers.

Byte (B). A sequence of n bits operated upon as a unit is called an n-bit byte. The most frequent size is 8 bits. KB stands for 1 024 bytes, and MB stands for 1 megabyte.

Bus. A group of wires that allow memory, CPU, and input/output devices to exchange data.

Clock. In a small computer, a device that sends out timing pulses to synchronize the actions of the computer.

COBOL. Short for "Common Business-Oriented Language"; a high-level language.

Computer Program (Program). A collection of instructions properly ordered to perform a particular task.

CPU (Central Processing Unit). That part of a computer system that controls the interpretation and execution of instructions. In general, the CPU contains the following elements: arithmetic-logic unit, timing and control, accumulator, scratch-pad memory, program counter and pointer stack, instruction register and decoder, parallel data and input/output bus, memory and input/output control.

Data Base. The entire collection of information available to a computer system. Or, a structured collection of information as an entity or collection of related files treated as an entity.

Data Base Management System (DBMS). Facilities for creating and maintaing a large, organized, structured collection of data and providing means for producing various types of predetermined reports based upon interrogation of the data base.

Data Set. A collection of data records, with a logical relation of one to another.

Digital. Of or pertaining to numerical bits.

Disk. A round piece of magnetic-coated material used to store data with greater density, speed, and reliability than with magnetic tapes. Floppy disks have thin 5-1/4 inch (13.3 cm) or 8 in. (20.3 cm) disks. Hard disks are thicker and can be much larger.

FORTRAN. A high-level language generally for scientific use, expressed in algebraic notation. Short for "Formula Translator".

Hardware. Physical equipment forming a computer system.

High-level Language. User-oriented programming languages using letters, symbols, or English-like text from which are generated codes the computer understands. FORTRAN, COBOL, and BASIC are three commonly used high-level languages.

Input-Output (I/O). General term for the process of communicating between the computer and external devices; or the data involved in that communication.

Mainframe Computer. A large-scale computer such as the IBM System 370 maxicomputer of a Digital VAX 11/370 minicomputer.

Memory. That part of a computer that holds data and instructions. Each instruction or datum is assigned a unique address that is used by the CPU when fetching or storing the information.

Microcomputer. A computer whose CPU is a microprocessor. A microcomputer is an entire system with microprocessor, memory, and input-output controllers.

Microprocessor. Frequently called "computer on a chip". The microprocessor is, in reality, a set of one, or a few, large-scale integrated circuits capable of performing the essential functions of a computer CPU.

Modem. Short for Modulator/demodulator. An electronic device that allows computer equipment to send and receive information through telephone lines.

Network. An interconnected group of computer systems, terminals, or communications facilities for sharing of data bases or computer processing resources.

Peripheral Device. Equipment that is external to the computer itself, for example, disks and printers.

Pascal. A high-level, structured programming language named after the 17th century French mathematician Blaise Pascal.

PL/I. A high-level, structured programming language combining features from COBOL, FORTRAN, and other languages. Short for "Programming Language One".

Software. Computer programs.

Terminal. An input-output device that interfaces between the human operator and the computer system, for example, a teletype or a video display terminal.

Video Display Terminal (VDT). A terminal containing a screen for viewing data entered into or received by the terminal. A cathode-ray tube is most commonly used resulting in the acronym CRT.

Table 1. Comparison of ICCAT's minicomputer performance and cost[1] (from Nördstrom and Miyake, 1978)

System models recommended	DIGITAL PDP-11 Model-34A	US$	HEWLETT-PACKARD 1000 Model 45	US$	IBM Series 1 Model E	US$	TEXAS INSTRUMENTS DS 990/10 Model 4	US$
HARDWARE								
Processor								
Memory	128K bytes		120K bytes		128K bytes		256K bytes	
Speed (cycle time)	725 n.s.				660 n.s.		725 n.s.	
Console	Printer (30 cps)		Screen		Screen		Screen	
I/O Devices								
Disks	14MB x 2		9.8MB x 2		64MB x 1		5MB x 4	
Av. access time	50.5 MS		33 MS		36 MS		35 MS	
Diskette magazine unit	—		—		28 MB		—	
Tape unit	800 BPI		800 BPI		—		800 BPI	
Printer	180 cps x 2		180 cps		150 l.p.m. (approximately 200 cps)		150 cps x 2	
HARDWARE COST:		103 367		—		77 271		91 560
SOFTWARE								
FORTRAN IV	Available		Available		Available		Available	
Utilities and sort	Available		Available		Available		Available	
SOFTWARE COST:		2 338				10 656		5 550
TOTAL PRICE		105 705		99 989		87 927		97 110
OPTIONAL								
Processor								
Memory	Up to 248KB		Up to 2MB (by unit of 128K)	8 071/128K	Up to 256KB	11 743	Up to 2MB	
Card reader	300 c/m	9 500	600 c/m	10 291	Not available		400 c/m	7 800
V D U (Screen)			Available	5 246	Available		Available	
Plotter	Not available[2]		280 x 400 mm	7 743	Not available[2]		Not available[2]	
Software (Data base managing system)	DATATRIEVE-11	6 493	IMAGE/120	4 571	Not available at present		Available	3 000

[1]Estimates for prices are valid for October-November 1978. Prices are given in pesetas and converted into US$.

[2]Any makes can be adopted.

Table 2. Comparison of minicomputer performance and cost (from Skillman, 1980)

System/Models Specifications	DEC PDP-11/34A	US$	FACOM V-830	US$ 6/	HEWLETT-PACKARD HP 1000, Mod 45	US$	IBM Series 1, Mod E	US$	Texas Instruments TI990/10 Model A	US$	Wang Model 2200 VS	US$
Basic configuration												
Central processor												
Memory	128K	n/c	262K	n/c	128K	n/c	128K	27 200 (operating system)	256K	n/c	128K	n/c
Speed (cycle time)	725 n.s.		400 n.s./2B		420 n.s.		660 n.s.	2 000	725 n.s.		660 n.s.	
Console	printer 30 cps	n/c	screen	n/c	graphics screen	n/c		1 700	screen	n/c	screen	n/c
Cost		54 000		45 700		43 500		30 900		34 500		21 800
Peripherals												
Main storage	disk 28MB (x2)	n/c	disk 40MB disk 40MB(x4)	n/c 9 400	disk 19.6 MB (x2)	n/c	64MB x 1	10 700	disk 5MB (x4)	7 800	disk 75MB (x4)	19 000/ unit
Backup storage	tape 1600bpi	17 000	tape 1600bpi	22 800	tape 800bpi	10 750	tape	17 500	tape 800bpi	10 000	tape 800/ 11600bpi	16 100
Printer	180 cps(x 2)	7 400	180 cps	9 582	180 cps	4 000		8 600	150 cps(x 2)	5 500	220 cps	10 350
Cost		24 400		41 782		14 750		36 800		23 300		45 450
Software												
FORTRAN IV	available	800	available	75/mo.	available	n/c	available 2/	870	available	1 000	available	n/c 3/
Utilities and sort	available	n/c	available	165/mo.	available	n/c	available	720	available	2 500	available	n/c
COBOL	available	?	available	75/mo.		n/a	available	870		n/a	available	3 450
Cost		800				0		2 460		3 500		3 450
Total cost		79 200		91 262		58 250		70 160		61 300		70 700
Options												
Memory up to	256K	4 000	512 KB	3 600/ 128KB	2 MB in 128K	3 500/ 128K	256K	1 510/ 16KB	1 MB	575/ 4Kwords	512K for VS 2 048K for VS 100	8 500/ 128K 10 350/ 128K
Card reader	300 c/m	7 000	600 c/m	17 030	600 c/m	6 375		n/a	400 c/m	5 200		n/a
Video display screen	available	2 200	available	3 862	available	3 500		n/a	available	2 000	available	2 900
X-Y plotter		n/a		n/a		2 600		n/a		n/a	not now available	
Data Base Software		4 500	available	200/mo.		3 000		n/a		2 000	available 4/	n/c
Word Processor Software											available 5/	3 000

1/ Cost estimates were quoted by west coast vendors in U.S.A. and may vary withthe site chosen in Indo/Pacific area.

2/ PL/1 language is also available.

3/ BASIC and PL/1 languages also available; Assembler and one higher order language included with price of system and each additional language cost $3.450.

4/ An advanced DBMS is available for $17 250.

5/ Word processor terminal (CPT) cost $4 376.

6/ CIF Manila

Table 3. Specifications, performance capability, and cost of an IBC Ensign Model E-1256 microcomputer

Specifications	Values	Cost US$
Basic configuration		
Central processor		10 850
Memory	256K	n/c
Speed (cycle time)	120 nsec	--
Console	Video	1 300
Subtotal		12 150
Peripherals		
Main storage	2, floppy disks (2.4MB	n/c
	Winchester disk (50MB)	8 200
Backup storage	9 track tape drive	2 250
Printer	150 cps	1 695
Subtotal		12 145
Software		
Basic	Available	290
COBOL	do	580
FORTRAN	do	350
Pascal	do	430
PL/I	do	460
Operating system cp/M	4 different systems	300
Subtotal		2 410
Total		26 705
Options		
Memory up to	768KB	4 200/256KB
Card reader	Not available from manufacturer	
Video display terminals	3 models	800 to 1 300
X-Y plotter	Available from other vendors	
Data base software	do	
Word processor software	do	

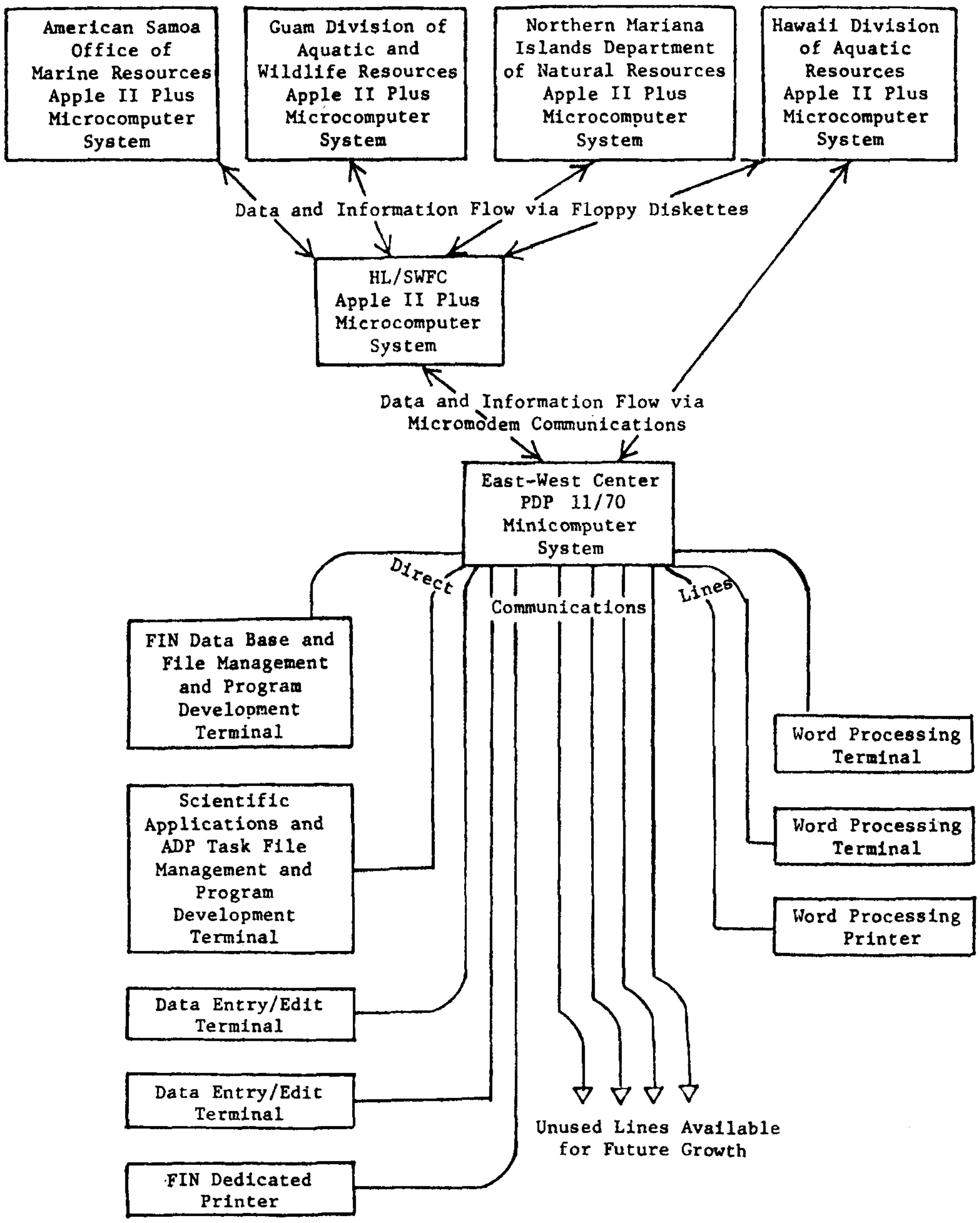

Figure 1. The WPACFIN hardware configuration (see text footnote 2)